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Nutritive studies on wild and cultivated blueberries

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INTRODUCTION

Blueberry, huckleberry and bilberry are names variously and contradictorily applied in different localities to certain species of Vaccinium. By New England custom, those of bluish color are popularly known as blueberries while those that are black or nearly so are called huckleberries. Botanically, blueberries and bilberries are ascribed to the genus Vaccinium and huckleberries to Gaylussacia. Physically, blueberries and bilberries are generally sweeter, milder, and larger than huckleberries, and the seeds, though more numerous, are much smaller and scarcely noticeable in eating the fruit.

Vaccinium corymbosum, the high-bush, cultivated type, and Vaccinium pennsylvanicum, a low-bush dwarf type, are the common species growing in northern New England, the Canadian Maritime Provinces, and Newfoundland. In the wild state, the blueberry is one of the most promising native fruits. Attempts to bring blueberries into profitable cultivation have been made with considerable success. The tall blueberry, propagated chiefly by cuttings from choice strains, yields the best results and often produces finely flavored berries three quarters inches in diameter. It is best grown in boggy areas in an acid soil, but with good drainage.

The low-bush variety is the one most widely used in

commercial canning, and provides the chief crop of some sections of Maine such as Washington county. In the areas of commercial production it is a semi-cultivated crop in that it is cropped a series of years and then the ground burned over and new bushes grown. The swamp or high-bush blueberry is more common in Massachusetts and is the type most largely used in this state. This berry is said to have more character and flavor than the low-bush type.

Blueberries are delicious when fresh and are very acceptable for pies when canned. More are probably canned than preserved in any other way. They are readily frozen and large quantities are preserved in the frozen state. A few blueberries are also dried. The blueberries used in these tests were secured from Maine, Massachusetts and New Jersey. The 1935 work was done on blueberries shipped weekly from the Wareham Experiment Station as long as the crop could be harvested. Some of the samples were frozen and some were canned.

REVIEW OF LITERATURE

1. History and Culture.

Duryee (1933) reviewed the early work on blueberries. Blueberry culture was founded by Dr. Frederick V. Coville, formerly botanist of the U.S. Department of Agriculture. In 1910 he published his bulletin entitled "Experiments

in Blueberry Culture". In this work, Dr. Coville swept aside the previously held notion that blueberries could be grown in ordinary agricultural soils and definitely showed that they need an acid peat soil. He showed that saturated soil is not the most ideal location for this plant, but that it does need considerable moisture. The cutting method of propagation was recommended. This was the very foundation of the industry.

Dr. Coville's work was not particularly startling in its time and its fame rests to a great extent on the use to which it was put. Miss Elizabeth C. White, of New Lisbon, N.J. saw the bulletin, read it with great interest, and immediately wrote to Dr. Coville offering to cooperate in his further experiments. Both recognized the advantages to be gained by such cooperation, so a plan of work was prepared and carried out over a period of twenty years.

The blueberry growing industry was rather slow in getting started because of the fact that it took two or three years for a bush to come into bearing, but as soon as some of the bushes were producing berries, great interest was expressed. Various growers procured plants of the selected varieties and set out new plantations. By 1927, there were enough growers to organize a cooperative selling organization. That organization, the Blueberry Cooperative Association, is predominant in the blueberry market at this time.

Beckwith and Coville (1931) have published an excellent bulletin on blueberry culture describing the varieties and giving pictures of same. Chandler and Mason (1933) reported that fertilizer for wild berries in Maine is often beneficial. Crowley (1928) of the state of Washington, Johnston (1934) from Michigan, Bailey and Franklin (1935) of Massachusetts, and Gourley (1917) at New Hampshire, have also published bulletins on the cultural aspects of blueberries in their respective states.

2. Composition.

Several foreign workers have carried on vitamin C determinations on blueberries. Hahn (1931) determined that blueberries were low in vitamin C with less than 10 guinea pig units. Lavrov, Yanovska, and Yurousova (1934) found stored huckleberries contained only traces of vitamin C. Murri and Kudryavtzeva (1934) found blueberries were a fair source of vitamin C. In America, Fellers and Isham (1933) showed Vaccinium corymbosum, the high-bush blueberry protected guinea pigs at a level of 4 to 5 grams, therefore giving about 2 U.S.P. units per gram. They found Vaccinium pennsylvanicum, the low-bush blueberry was only one-fourth as high in vitamin C content as V. corymbosum. Remington (1930) reported the blueberry contained 206 parts per billion of iodine on the dry basis when grown in South Carolina on soil rich in iodine.

Atwater and Bryant (1906) reported the percentage compo-

sition of blueberries as purchased: water, 85.6; protein, 0.6; fat, 0.6; total carbohydrate including fiber, 12.8; ash, 0.4. Sherman (1934) has tabulated blueberries as containing 0.02 per cent phosphorus and 0.025 per cent-calcium figured as percentage of edible portion. In parts per million of edible portion, the iron is 9 and manganese 44. Hodges and Peterson (1931) found blueberries rather high in manganese in comparison with other fruits. Chandler and Mason (1935) reported the chemical analysis of the blueberry ash to indicate that blueberries are only a fair source of calcium, poor in phosphorus, and good as a source of iron. They do not give any data.

STATEMENT OF PROBLEM

In general the literature covers only wild blueberries and the object of this study was to compare several varieties of cultivated blueberries with the high-bush and low-bush varieties. Proximate chemical analyses were made on six cultivated varieties and the two types of wild. Since vitamins are among the important components of fruits from a nutritive view point, a study of the vitamins A and C of blueberries was undertaken. Since the pigment interfered with titration methods of vitamin C determination, the Sherman guinea pig assay method was used exclusively in this study. Each animal assay requires 90 days.

METHODS

The method of Sherman, La Mer and Campbell (1922) was used for vitamin C. The animals were all young and healthy, weighed between 250 and 325 grams, and were kept in individual cages. The basal ration consisted of 58 per cent equal parts of rolled oats and wheat bran, 30 per cent of vitamin C-free baked skim milk powder, 10 per cent butter fat, 1 per cent each of cod liver oil and salt. This basal ration and water were kept before the animals at all times. Three guinea pigs normally were used at each feeding level, though in some cases only two were used. At the end of the feeding period all animals were chloroformed, autopsied, and carefully examined for lesions of scurvy. Negative controls died within thirty days with a Sherman scurvy score of 16 to 20.

The U.S. Pharmacopeia (Tenth Revision) technic was used for vitamin A. The depleted rats were fed the vitamin A-free diet, consisting of 65 per cent cornstarch, 18 per cent vitamin-free casein, 8 per cent irradiated yeast, 5 per cent Crisco, and 4 per cent salt mixture. This was supplemented by blueberries as the sole source of vitamin A.

The moisture was determined by the toluene method of Bidwell and Sterling (1925) and checked by the official

Methods of Analysis of the Association of Official Agricultural Chemists (1925), page 209. The principle of the toluene moisture determination is that toluene boils at 110°C. and thus allows the water to boil and be condensed into a volumetric tube which reads directly in cubic centimeters of water per given quantity of berries (usually 5 grams).

The protein was determined by the Kjeldahl method as described in the official methods of the Association of Official Agricultural Chemists, (1925); the ash; crude fiber, and ether extract also as in the official methods.

The first year, 1934, the frozen berries were packed in glass jars, some with rubber rings and some without, though those with rings are to be preferred. They were packed as soon as they arrived and immediately taken to the cold storage freezing room at the College. As they were needed they were brought down and kept in the dairy cold room. In 1935 all frozen berries were packed in tin cans and frozen at the dairy building and kept there until used. The cold storage plant is not too satisfactory in keeping a constant temperature and it is believed that the berries of the first year were defrosted and refrozen once or more times.

DISCUSSION OF PROXIMATE ANALYSIS OF BLUEBERRIES

Table 1 shows the proximate composition of blueberries and it is self-explanatory. In general they show a high water content as do most fruits with the protein, fat and ash low. The soluble solids (sugars) are relatively high and furnish a good source of energy. The percentage moisture determinations on V. corymbosum (wild high-bush) averaged 84.0; on V. corymbosum (cultivated high-bush) Cabot variety, 76.0; Harding variety, 83.0; and Rubel variety, 85.0. The soluble solids (by refractometer) varied in the fresh fruit from 11.3 to 11.9 per cent with a mean value of 11.6 per cent.

The analyses show rather unimportant differences in phosphorus and potassium content. The latter element constitutes over 50 per cent of the total ash. It is significant that phosphorus is higher than calcium. In the sample of Rubel variety from Wareham the calcium content is less than half that of either of the wild species. Magnesium and manganese are also lower in the Rubel variety than in the other two samples. The Maine blueberry (V. Pennsylvanicum) was particularly high in manganese content.

The ash analysis shows the blueberry to contain the usual minerals found in plant tissues. There is a definite excess of alkaline elements in the ash.

DISCUSSION OF VITAMIN C RESULTS

Table 2 gives the summary of the assay work on culti-

vated varieties for vitamin C. Samples 1, 2, 7, and 8 were fed to the guinea pigs in the frozen state. Samples 3, 9, 14, and 18 were frozen but were defrosted at least once, and were refrozen before they were given to the animals. Sample 13 (Harding variety) was fed fresh for one month but the sample probably lost much of its vitamin C during this storage period. Frozen berries were fed for the other two months. All other samples in Table 2 were fed fresh for one month (weekly shipment) and fed frozen the other two months. This arrangement was due to the relatively short season when the fresh could be shipped from Wareham.

Table 3 summarizes the vitamin C studies on wild blueberries. The Maine berries were of the low-bush type, V. pennsylvanicum, grown at Cherryfield, Maine. Samples 28, 29, and 30 were assayed in 1935 and the others in 1934. It will be noted that the kettle cooked, commercial canned blueberries protected the animals from scurvy as well as the frozen fruit. This may be due to the immediate destruction of oxidizing enzymes which does not occur when the fruit is packed directly into the cans.

Figures 1, 2, and 3 give the weight changes and vitamin C results in graphic form for some of the experimental animals. A good weight gain, 100 grams for example, usually indicates scurvy protection. In general, freedom from scurvy is associated with marked and continued weight gains.

DISCUSSION OF VITAMIN A RESULTS

The experimental work on vitamin A has not been as extensive as on vitamin C. Previous work by Fellers and Isham (1933) would seem to show very little A present. Table 5 shows, in brief, a summary of our material and it would appear that there is about 1 U.S.P. unit per gram of blueberries. This shows that, although blueberries are not a good source of vitamin A, yet the presence of this amount is worthy of consideration.

SUMMARY

1. Analyses of fresh and moisture-free blueberries, wild (high-bush and low-bush) and cultivated, are reported. In general the fruit is characterized by high moisture, a medium amount of sugar; and the other four constituents are low, namely ash, ether extract, protein and fiber contents.

2. Blueberries are only a fair source of vitamin C. Seven grams are necessary to protect a 300-gram guinea pig from scurvy. Frozen blueberries are as good a source of vitamin C as are fresh blueberries, provided they have not been defrosted and refrozen. Defrosting of frozen blueberries resulted in almost complete loss of vitamin C. Kettle-cooked canned blueberries are protective to guinea pigs at a 10-gram level. There is little difference in variety though our work showed the Rubel and Cabot varieties to protect at a slightly lower level than the Harding and Pioneer. The range in vitamin C units per gram for the four cultivated varieties is 1.0 to 1.3 units. Vaccinium pennsylvanicum (wild low-bush type from Maine) contained 0.8 units of vitamin C per gram when frozen or canned (kettle cooked).

3. Blueberries are not a good source of vitamin A, but there is about one U.S.P. unit per gram of the blueberries.

BIBLIOGRAPHY

Association of Official Agricultural Chemists. 1925
Methods of Analysis. Assoc. Official Agric. Chemists.
Washington, D.C. Second Ed. Ch. XIV.

Atwater, W. O. and Bryant, A. P. 1906.
The Chemical Composition of American Food Materials.
U.S. Dept. Agric. Bull. 28 (Revised Edition).

Bailey, J. S. and Franklin, H. J. 1935
Blueberry Culture in Massachusetts.
Mass. Agric. Expt. Sta., Bull. 317.

Beckwith, C. S. and Coville, S. 1931
Blueberry Culture.
N.J. Agric. Expt. Sta., Cir. 229.

Bidwell, G. L. and Sterling, W. F. 1925
Preliminary Notes on the Direct Determination of
Moisture.
Ind. Eng. Chem. 17: 147-149.

Chandler, F. B. and Mason, I. C. 1933
Effects of Fertilizer on the Native Maine Blueberry.
Proc. Amer. Soc. Hort. Science. 30: 297-8.

Chandler, F. B. and Mason, I. C. 1935
Blueberry Investigations. Chemical Composition
Maine Agr. Expt. Sta. Bull. 380, 217.

Coville, F. V. 1921

Directions for Blueberry Culture.

U.S. Dept. Agric. Bull. 974.

Crowley, D. J. 1928

Blueberry Growing - A New Industry in Washington.

State College of Washington Agric. Expt. Sta.,

Popular Bull. 144.

Duryee, W. B. 1933

A Survey of the Cranberry and Blueberry Industries in New Jersey.

N.J. Dept. Agric., Cir. 232, 30-34.

Fellers, C. R. and Isham, P. D. 1933

Vitamins C and A in Blueberries.

J. Agric. Res. 47: 163-165.

Gourley, J. H. 1917

The Blueberry in New Hampshire.

N. H. Agric. Expt. Sta., Bull. 317.

Hahn, v. F. V. 1931

The Vitamin Content of Fruits.

Ztschr. Untersuch. Lebensmtl. 61: 369-411, 545-611.

Abstract in Expt. Sta. Rec. 68: 860.

Hodges, M. A. and Peterson, W. H. 1931

Manganese, Copper and Iron Content of Serving Portions of Common Foods.

J. Amer. Dietetic Assoc. 7: 6-16.

Johnston, S. 1934

The Cultivation of the Highbush Blueberry.

Mich. Agric. Expt. Sta., Special Bull. 252.

Lavrov, B. A., Yanovska, B. I. and Yarousova, N. S. 1934

Contents of Antiscorbutic Factor in Huckleberries Stored During the Winter and in Preserves of Black-currant Juice.

Questions of Nutrition (U.S.S.R.) 3: 29-31. Abstract in Chem. Abstracts, 29: 5939.

Murri, I. K. and Kudryavtzeva, A. V. 1934

The Influence of Treating Berries and Fruits on the Potency of the Anti-scurvy Vitamin.

Bull. Applied Botany, Genetics Plant Breeding (U.S.S.R.) Suppl. 67: 71-88. Abstract in Chem. Abstracts, 28: 7317.

Remington, R. E. 1930

Unanswered Questions in the Biochemistry and Geochemistry of Iodine.

J. Chem. Educ. 7: 2590-99.

Sherman, H. C. 1934

Food and Health. 216.

The MacMillan Co.

Sherman, H. C., La Mer, V. K., and Campbell, H. L. 1922
The Quantitative Determination of Antiscorbutic Vitamin (vitamin C).
J. Amer. Chem. Soc. 44: 165-172, illus.

U. S. Pharmacopoeia. 1934
Revision of the Text and Assays for Cod Liver Oil.
6-8.

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Table 1. Composition of Blueberries (Moisture Free Basis)

Sample number	Species and Variety	Crude protein (Nx6.25)	Ether extract	Extract matter (sugars)	Fiber	Ash
	Wild	per cent	per cent	per cent	per cent	per cent
1	V.pennsylvanicum, Heath, Mass.	3.75	3.18	85.26	6.53	1.28
2	V.pennsylvanicum, Cherryfield, Me.	3.14	2.13	86.49	6.83	1.41
3	V.corymbosum, Goshen, Mass.	3.91	3.36	82.58	8.79	1.36
4	V.corymbosum, Amherst, Mass.	4.69	4.69	76.46	12.58	1.58
	Cultivated					
5	V.corymbosum, Cabot, East Wareham, Mass.	4.17	2.97	85.44	6.17	1.25
6	V.corymbosum, Concord, Whitesbog, N.J.	4.37	3.35	85.62	5.16	1.50
7	V.corymbosum, Harding, East Wareham, Mass.	3.78	3.91	82.69	8.23	1.39
8	V.corymbosum, Jersey, Whitesbog, N.J.	3.05	3.34	84.38	7.82	1.41
9	V.corymbosum, Pioneer, East Wareham, Mass.	3.22	2.82	86.96	5.55	1.45
10	V.corymbosum, Rubel, East Wareham, Mass.	4.02	3.26	83.77	7.55	1.40

Av. moisture content of wild blueberries, 84.0 per cent; of the cultivated varieties, 81.3 per cent.

Analyses on samples 2, 3+4, and 10 show the following respective percentage composition: P_2O_5, .19, .21, .23: K_2O, .52, .59, .64: CaO, .176, .166, .074: MgO, .101, .115, .067: $Fe_2O_3 + Al_2O_3$, .014, .019, .014: Mn, .0194, .0058, .00061: and insoluble matter, .02, .01, .009.

Table 2. Tabulation of Data on Vitamin C Bioassays on Cultivated Blueberries

Sample number	Variety of V.corymbosum	Year	Quantity fed daily	Average survival period	Total av.wt. gains	Sherman scurvy score	Estimated protective level	Vitamin C international units
			Grams	Days	Grams	Average	Grams	Per gram
1	Pioneer	1934	3	47	-144	9		
2	Pioneer	1934	6	86	- 19	7		
3	Pioneer *	1934	10	27	-110	9		
4	Pioneer	1935	7	90	81	4	9-10	1.05
5	Pioneer	1935	12	90	298	0		
6	Pioneer	1935	18	90	296	0		
7	Rubel	1934	3	81	-113	12		
8	Rubel	1934	6	81	- 46	8		
9	Rubel *	1934	10	29	-164	8		
10	Rubel	1935	7	90	226	0	7- 8	1.33
11	Rubel	1935	12	90	149	0		
12	Rubel	1935	18	90	266	0		
13	Harding	1934	6	57	-112	7		
14	Harding *	1934	12	31	-137	7		
15	Harding	1935	7	90	99	4	9-10	1.05
16	Harding	1935	12	90	173	0		
17	Harding	1935	18	90	222	0		
18	Cabot *	1934	15	45	-118	15		
19	Cabot	1935	7	90	269	0	7 -8	1.33
20	Cabot	1935	12	90	206	tr.		
21	Cabot	1935	18	90	332	0		

* Defrosted

Table 3. Summary of Data on Vitamin C Bioassay of Wild Blueberries

Sample number	Description and treatment	Quantity fed daily	Av. survival period	Total av. wt. gains	Sherman scurvy score	Estimated protective level	Vitamin C Intern. units
		Grams	Days	Grams	Average	Grams	Per gram
22	Me. low-bush, kettle cooked; canned at 190° F.; no exhaust	10	90	139	1	12-13	0.8
23	Same as sample 22.	20	81	225	0		
24	Sample 22, frozen while fresh	10	90	232	1	11-12	0.87
25	Me., unblanched, filled cold, exhausted to 190 F., sterilized 15 min. at 212°F.	12	62	- 47	7	> 12	< 0.83
26	Me., blanched 30 sec., not cold-dipped, sterilized 10 min. at 212° F.	20	48	-143	12	> 20	< 0.5
27	Same as sample 26, except unblanched.	20	28	-131	15	> 20	< 0.5
28	Me. commercial, pie pack, canned.	8	36	-153	14		
29	Same as sample 28.	10	36	-113	16		
30	Same as sample 28.	15	33	-121	12	> 15	< 0.75
31	Mass. high-bush, unblanched, canned; sterilized 10 min. at 212° F.	6	37	-126	14		
32	Same as sample 31.	10	29	-107	13	> 10	< 1.0
33	Mass., high-bush, treated like sample 26.	10	30	- 60	11	> 10	< 1.0

Samples 22 - 30 are V. pennsylvanicum; Samples 31-33 are V. corymbosum.

Table 4. Summary of Vitamin C Results on Blueberries

Variety	International units of vitamin C	
	per gram	per ounce
Cabot	1.33	37.6
Rubel	1.33	37.6
Harding	1.05	29.7
Pioneer	1.05	29.7
Maine, kettled, canned	0.8	22.6
Maine, frozen	0.87	24.6

1 International unit of vitamin C = .05 mg. ascorbic acid

10 International units required for guinea pig to protect against scurvy.

Table 5. Summary of Vitamin A Results on Blueberries

Supplement and amount	No. of rats	Average depletion period	Average gain in weight	Vitamin A content per gram
		days	grams	U.S.P. units
500 mgs. dried wild high-bush	7	31	-2	trace
3 g. frozen cultivated	8	32	27	1.05
5 g. frozen cultivated	7	34	29	.67
5 g. frozen wild high-bush	7	45	21	.50
Ref. oil	5	45	23	5,700.

1 U.S.P. unit of vitamin A = 0.6 gamma (micrograms) of carotene, or that which will give an average weight gain of 3 grams per week for 4 weeks to not less than 6 out of 8 rats.

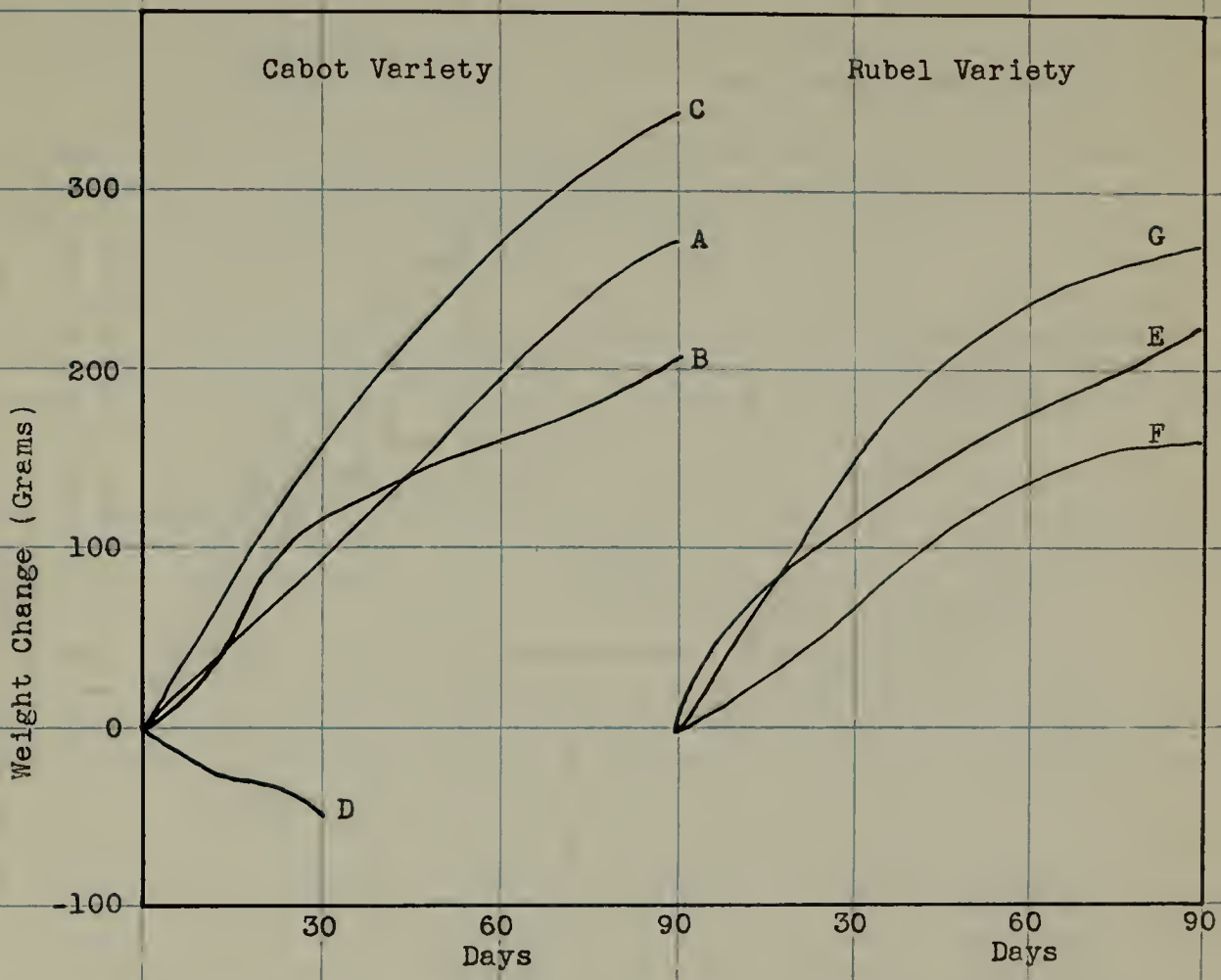

Figure 1. Results of feeding guinea pigs Cabot and Rubel varieties of cultivated blueberries as the sole source of vitamin C: A, 7 g. Cabot, scurvy score, 0; B, 12 g. Cabot, scurvy score, trace; C, 18g. Cabot, scurvy score, 0; D, negative control, scurvy score 17; E, 7 g. Rubel, scurvy score, 1; F, 12 g. Rubel, scurvy score, 0; G, 18 g. Rubel, scurvy score, 0.

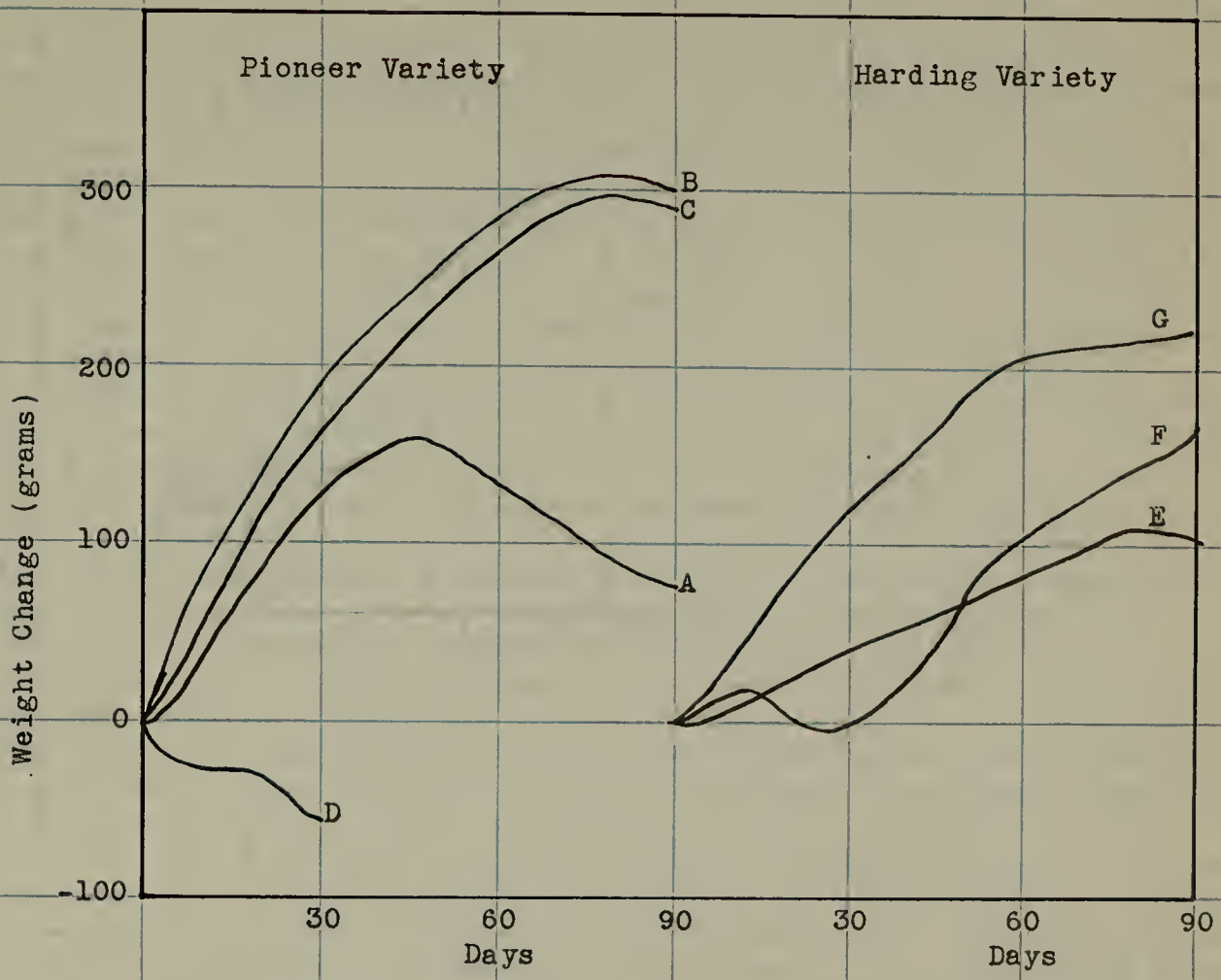

Figure 2. Results of feeding guinea pigs Pioneer and Harding varieties of cultivated blueberries as the sole source of vitamin C: 7 g. Pioneer, scurvy score, 4; B, 12 g. Pioneer, scurvy score, 0; C, 18 g. Pioneer, scurvy score, 0; D, negative control, scurvy score, 17; E, 7 g. Harding, scurvy score, 4; F, 12 g. Harding, scurvy score, 0; G, 18 g. Harding, scurvy score, 0.

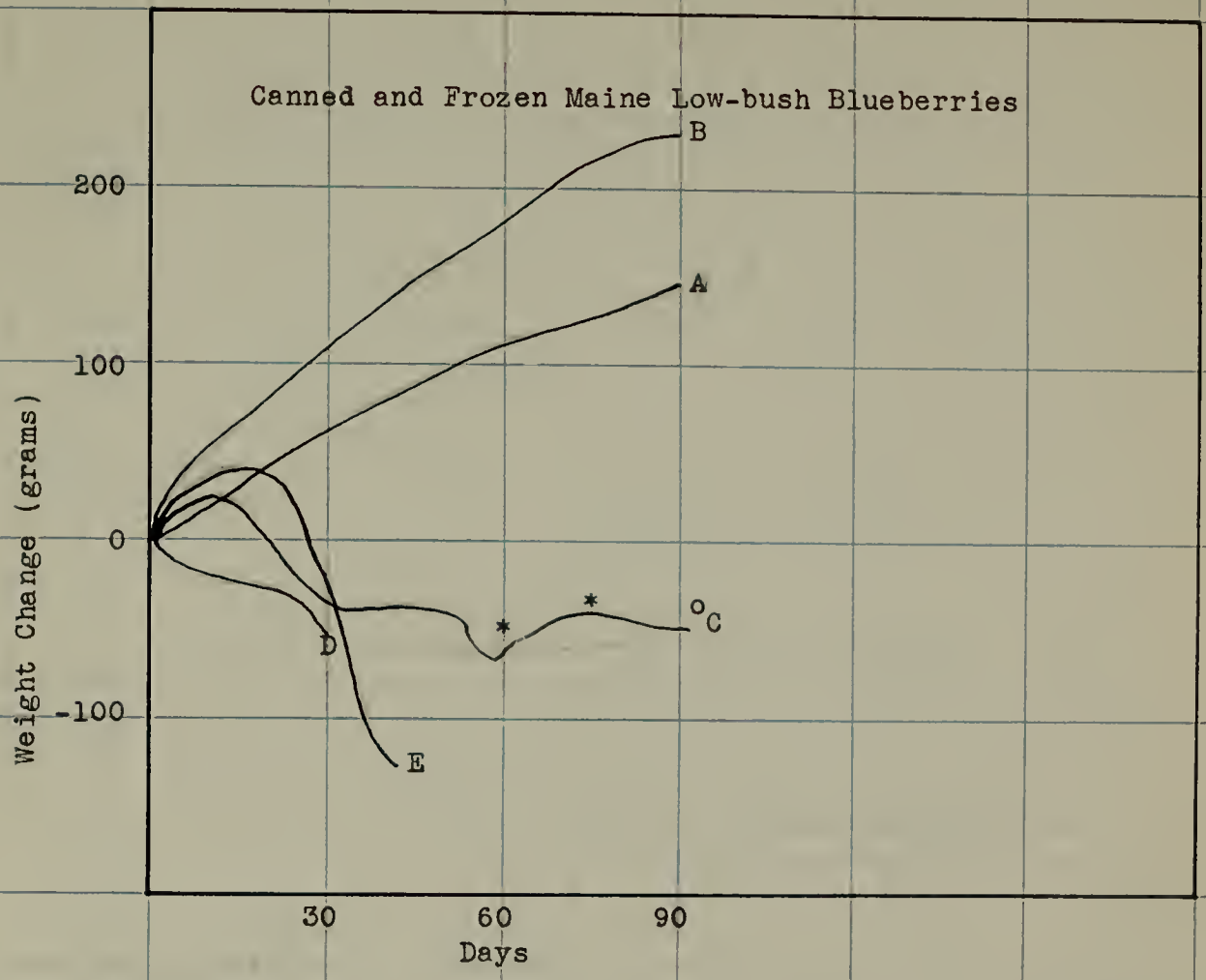

Figure 3. Results of feeding guinea pigs canned and frozen blueberries as the sole source of vitamin C; A, 10 g. Maine, kettle cook, canned, scurvy score, 1; B, 10 g. Maine, frozen, scurvy score, 1; C, 12 g. Maine, canned (not blanched), scurvy score, 7; D, negative control, scurvy score 17; E, 15 g. Maine pie pack, scurvy score, 16.

* Animals died at these points

o One surviving animal

Approved by

Carl R. Fellers

James E. Fuller

Helen Knowlton

Graduate Committee

Date May 29, 1936

Rendition Chart